Pest Management Grants Final Report

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Contract Title: A Demonstration of Refined Pest Management Strategies for Rice Water Weevil in California Rice

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Disclaimer

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Abstract

The effectiveness of a modified insecticide strategy and a cultural technique for controlling rice water weevil was evaluated in field studies. Two insecticides, that will be applied after field flooding, are in the registration process. The standard method is to use an insecticide before flooding which allows the product to be targeted to the areas that will be most severely infested. A key question regarding these new products, Dimilin® 2L and Warrior® 2EC, is if they will provide efficacious rice water weevil control with this targeted application method, i.e., applied only to the field borders compared with applications to the entire field. Averaged over five locations, good rice water weevil larval control was seen with Dimilin and the border method produced only slightly less effective control compared with the entire field treatment. For Warrior, studies were conducted in four grower field locations and the border and entire field treatments both provided excellent larval control. However, plots treated with both of these new materials yielded less than those treated with the standard product, Furadan®. Previous small plot research has shown that lower rice water weevil larval populations occur during the growing season in areas that were winter-flooded compared with non-flooded areas. This research in 1998 was extended to larger plots and to grower fields; however, the unfavorable winter and spring conditions greatly compromised this objective.

Executive Summary

The efficacy of a modified insecticide strategy and a cultural control technique on rice water weevil (*Lissorhoptrus oryzophilus* Kuschel) was evaluated in field studies. The specific objectives of this work were 1.) to investigate the effectiveness of post-flood border insecticide treatments for the management of rice water weevil larvae in California rice and 2.) to demonstrate the effectiveness of a cultural technique, winter rice field flooding, for the management of rice water weevil in California rice. Preplant applications of a granular insecticide are the standard method of controlling rice water weevil in California; generally application is made only to the basin borders. Registration of the insecticide used for this treatment, Furadan, is scheduled for cancellation. Since 1991, the registration has been under scrutiny and the registration will likely be canceled when alternatives are available. Two products, Dimilin® 2L and Warrior® 2EC, used as post-flood treatments are in the registration process. These along with a preplant, incorporated product, Icon®, form viable alternatives to Furadan. Economic rice water weevil populations generally only occur in the first 30-50 feet of the basins adjacent to the levees. Therefore, the standard application method with Furadan is to apply the insecticide only to this area. This method provides effective control and has the positive attributes of reducing the amount of insecticide used, cost, potential exposure, etc. A key question regarding the use of post-flood products is if they will provide efficacious rice water weevil control when applied only to the borders of the basins compared with applications to the entire basins. The optimal timing for these post-flood products is approximately the 3 rice leaf stage. There is very little foliage leaf area to intercept the insecticide at this time; most of the insecticide goes into the water. With a border treatment and having only ~15% of the basin treated (varies with size and shape of basin), the mixing of treated and untreated water may dilute the insecticide concentration and render the application ineffective. Studies for this objective were conducted in nine grower fields in 1998. Data were collected at all sites on the percentage of rice plants with adult damage, larval population magnitude per 4 inch diameter core sample, and rice grain yield.

Across five sites, averages were 1.3 rice water weevil per core sample (untreated), 0.2 (Furadan), 0.3 (Dimilin full basin), and 0.7 (Dimilin border treatment). Rice water weevil infestations were above threshold levels at two sites and Dimilin reduced the larval population below the economic threshold in both cases. There were no differences between the border and entire basin treatments (75.4% reduction in the entire basin treatment and 69.1% reduction in the border treatment) at these sites. Yield data, collected from hand-harvested samples ~10 feet from the levees, showed that overall the yields were lower in the Dimilin border treatment than in the Dimilin full treatment and that both of these yields were lower than with Furadan. With the machine harvest yield data, the yields of the three insecticide treatments, and the untreated, were more similar, but the same trends were seen as with the hand-harvests. For the other prospective rice water weevil product (Warrior), studies were conducted in four grower field locations. Averaged over these four sites, untreated basins averaged 1.7 larvae per core sample compared with 0.07 for the Warrior full basin treatment. The border Warrior treatment was comparable with 0.08 rice water weevil per core. Furadan resulted in 0.3 rice water weevil per core. Yield data showed that the Warrior treatments yielded more than the untreated but substantially less than the Furadan. There were no obvious differences in the yields between the border and full basin Warrior treatments. Additional data are needed to expand the database and to further examine this area over a range of field locations, years, environmental conditions, etc. Cultural controls are presently used, in part, to manage rice water weevil populations. Previous small plot research has shown that lower rice water weevil larval populations occur during the growing season in areas that were winter-flooded compared with non-flooded areas. This research in 1998 was extended to larger plots and to grower fields. The unfavorable winter and spring conditions greatly compromised this objective. Most rice fields were flooded to some extent during the winter of 1998. Three locations were examined. Rice plants were evaluated for rice water weevil adult feeding incidence, egg deposition, and larval population density. At one location, there were no differences in rice water weevil adult feeding incidence, oviposition, or larval densities between the winter-flooded and non-flooded. At a Sutter County grower field site, there was a tendency for a lower rice water weevil infestation in the winter-flooded site than the non-flooded field, but the data were inconclusive. A more favorable year in terms of weather will allow us to make more progress towards this objective.

Body of Report

<u>a. Introduction:</u> The Rice Water Weevil (Lissorhoptrus oryzophilus Kuschel) is the most important insect pest of rice in California. Although initially found in California in 1959 in only a relatively small geographical area (Lange and Grigarick 1959), this insect quickly spread throughout the Sacramento Valley rice production region. The spread was about 20 miles per year (Grigarick 1992). Rice is an important agricultural crop in California with about 500,000 acres per year and a total value of $4-5 billion per year (California Rice Promotion Board 1990). In the Sacramento Valley, the economies of many communities depend heavily on rice production. The poorly drained clay soils and environmental conditions in these areas limit cropping possibilities to only a few crops with rice being ideally suited. In California, rice yield losses of 10-30% from rice water weevil infestations can occur. This is the only insect that generally reaches damaging levels in California rice.

The rice water weevil in California originated from the southern states rice production area. However, there are several differences between the pest and pest severity between the two production areas. Due to significant differences in rice production systems and regional populations of rice water weevil, geographic specific research is required to include the spectrum of differences known to exist. The differences include: 1.) the variation in the biology of the major insect pest, i.e., rice water weevil reproduces by sexual means in Arkansas, Louisiana, Texas but in California only females are present and reproduction is parthenogenic; and, rice water weevil have 2 to 3 generations per year in Louisiana, one generation and a partial second in Arkansas and Texas, and one generation per year in California; 2.) the diversity and importance of other rice arthropod pests, i.e., rice stink bug, armyworms, rice stalk borer, rice seed midges in Arkansas, Louisiana, and Texas, and rice seed midges, tadpole shrimp, and armyworms in California); 3.) rice water weevil larval density causing economic damage in Louisiana and Texas is 5 per core sample, 10 larvae per core in Arkansas, and one larvae per plant in California); 4.) the method of rice establishment, i.e., in areas of Louisiana and all of California seed is applied directly into the water, whereas in Arkansas, Texas, and areas of Louisiana seed is placed directly into soil and with permanent flood applied approximately 5 weeks later.

In California, this pest overwinters as an adult in a diapause state. As the spring temperatures increase, the weevils break the diapause and eventually (during April to June) fly to and infest newly-flooded rice fields. Those fields with rice plants emerging through the water are most susceptible to infestation. The adults feed on the leaves of rice plants which results in characteristic longitudinal feeding scars. This feeding has no effects on rice growth or yield; however, coinciding with this the adults oviposit in the rice leaf sheaths found just below the water level. Eggs hatch in 3-5 days; the first instar larvae feed on the leaf tissue for a few days and then drop down through the water and soil to the roots. The remaining portion of the life cycle is spent in the flooded soil of rice fields. The larvae develop through four instars and feed on rice roots causing significant damage. Pupation occurs on the rice roots and new adults emerge in late July. These adults feed to a limited extent on rice leaves, then leave the rice fields for overwintering sites.

Management of rice water weevil in California relies on chemical and cultural controls. Biological control of this pest is nonexistent. Much research has been conducted on rice host plant resistance to rice water weevil. Thus far, some moderate resistance has been identified and is being incorporated into commercial varieties. This research has not yet reached the end user and does not appear to be a stand-alone management tool.

Chemical control of rice water weevil has relied on carbofuran (Furadan® 5G) since the late 1970's. This has been the only insecticide registered for rice water weevil management. This product has been and still is extremely effective for control of this pest. Carbofuran is used in California, as a pre-flood incorporated treatment, on about 35-40% of the rice acreage; usage in 1994 and 1995 was 62,000 pounds active ingredient each year. This usage figure represents a much higher number of fields because most growers apply carbofuran to the first ~30 feet of the basin nearest the levee (the area of high larval densities). This border treatment results in significant savings to growers and greatly reduces the amount of insecticide going into the rice agroecosystem. Since 1991, the registration of Furadan has been tenuous. Following several extensions, the product has been used through 1998 and now the availability is uncertain in 1999.

Three alternatives to Furadan are being researched and are in the registration pipeline.

There are unanswered questions regarding the efficacy of these products (diflubenzuron [Dimilin®], fipronil [Icon®], and lambda-cyhalothrin [Karate®, Warrior®]), but all can provide effective rice water weevil management. The most pressing questions are the application timing with the post-flood materials, Dimilin and Warrior, and of even more importance in terms of this proposal is the question of whether border applications will still be a viable option with post-flood treatments. Diflubenzuron and lambda-cyhalothrin manage rice water weevil by minimizing the deposition of viable eggs; they have no effects on rice water weevil larvae, which is the damaging stage. The optimal timing for diflubenzuron and lambda-cyhalothrin appears to be about the 3-leaf stage. The first two leaves of a rice seedling are below the water surface, therefore there is very little foliage above the water to receive the insecticide. Most of the spray will go into the water. The water movement and mixing/dilution of the toxicant may result in border applications not being a viable option with these post-flood materials. If border treatments cannot be used, insecticide usage for rice water weevil will greatly increase and amount of insecticide going into the rice agroecosystem will be magnified.

The existing cultural controls are of some utility for management of rice water weevil in California. They are 1.) removal of levee vegetation in the spring which may reduce rice water weevil densities in the adjacent rice basins, 2) dry (drill) seeding rice and 3.) delayed seeding dates. All of these methods present some important environmental, agronomic, or production limitations. Winter-flooding of rice fields is being increasingly used as a means to enhance the degradation of rice straw in lieu of burning. A group of University of California scientists have been studying the influence of straw management techniques on the rice agroecosystm. In these small plots studies, my laboratory has found that winter-flooding reduces populations of rice water weevil. Our research has all been conducted at one study location near Maxwell, and to validate this cultural control technique, studies need to be expanded to a broader area. The additional research will allow us to determine how robust this cultural control tool may be.

<u>b. Materials and Methods:</u>

Objective 1: To investigate the effectiveness of post-flood border insecticide treatments for the management of rice water weevil larvae in California rice.

Border versus full basin treatments of Dimilin® and Warrior® were examined in 1998 at five and four sites, respectively. At each site, a border treatment of the perimeter of the basin, generally one aerial application swath (~35 feet), was compared with neighboring basin(s) in which the entire basin was treated with the insecticide. Application timings were based on previous research and were determined to be the 3 leaf stage for Warrior and 5 days after 50% plant emergence through the water (also about the 3 leaf stage) for Dimilin. All applications were made with a fixed wing aircraft at 5-10 GPA. The applications were made under an Experimental Use Permit for Dimilin and a Research Authorization for Warrior.

The following samples were taken in each basin. Dates of seeding, application, and sampling are reported in Table 1. Sampling was concentrated at ~10 to 15 feet from the levee so as to have the highest rice water weevil infestation. The question was if the active ingredient in the border treatment would dilute so fast that control would not be achieved in this area.

1. Plant scarring - evaluation of the incidence of rice water weevil scarring on plant leaves and the percentage of the plants with scars on either of the two newest leaves was

determined from 100 plants per sample. Evaluations were done 3-4 weeks after seeding and about 1 week after application.

2. Laval numbers - the number of rice water weevil larvae per soil core (4 inch diam. by 6 inch deep) was determined twice, about 6 and 7-8 weeks after seeding. The soil and associated plants were processed to recover the rice water weevil larvae and pupae. A washing-flotation technique was used for this step. Twenty samples were taken per treatment per date.

3. Grain yield - rice grain yield adjusted to 14% moisture was quantified in all basins. Hand-harvest samples, 1 sq. m., were taken in each basin. Rice was clipped, the grain was threshed and weighed. If possible, yield samples were also collected with commercial equipment provided by the grower cooperators.

Objective 2: To demonstrate the effectiveness of a cultural technique, winter rice field flooding, for the management of rice water weevil in California rice.

The original goals for objective 2 were partially fulfilled. Studies comparing winter-flooded and non-flooded fields needs to be arranged in the fall and early winter. Winter-flooding of fields is typically done in November. The 27 January date of award notification hindered this. Communicating with growers in the fall will reduce this problem. With this in mind, the original plan was to find paired (flooded and non-flooded) fields. This could normally be done albeit with considerable effort but we had a severe problem in that the winter and spring precipitation resulted in most of the rice fields being "winter-flooded". In spite of these challenges, we did make significant progress toward this objective as outlined below.

The influence of winter-flooding on rice water weevil populations was examined at three locations. However, some compromises were made at each location. Scarred plant and larval data were collected as previously described. In addition, rice water weevil oviposition was monitored 2 to 3 times per week from ~14 to ~30 days after seeding. Seedlings (40/date) were collected and held in the laboratory until newly eclosed larvae appeared. These larvae were counted to estimate oviposition timing and magnitude. This aspect was added to the work originally proposed.

Studies were conducted at the straw management study (site of our previous work) near Maxwell (Colusa County). At this site, winter-flooded and non-flooded comprise the main plots and straw removal treatments (burning, baling, rolled, and incorporated) are the subplots. We have been collecting data at this location for the past 4 years and the winter-flooding has consistently reduced rice water weevil larval densities. The straw removal treatments have shown no effects. In 1998, we sampled the winter-flooded versus non-flooded main plots. This resulted in ~7 acre plots (with 4 replicates). This plot size is not atypical of grower basins. Unfortunately, the entire site was flooded from 3 to 17 February 1998. We also sampled a similar study near Biggs, CA. This site has the same treatments and is entering its third year. We have not previously worked at this site. The drawback with this site is that Furadan was used for rice water weevil larval control. This allowed us to collect only oviposition and scar data, but rice water weevil larval densities could be quantified because of the insecticide treatment. Furadan does not influence the adult feeding, survival and the incidence of scarred plants. The final comparison was in grower fields in Sutter County. Two nearby fields were used, but the planting dates were 14 days apart because of the unfavorable spring conditions for planting. In addition, the early-seeded (winter-flooded) field of this comparison was treated with Furadan.

A more favorable year in terms of weather will allow us to make more progress towards this objective. With the earlier notice of funding for 1999, we have already set-up seven comparisons in grower fields of winter-flooded and non-flooded.

<u>c. Results:</u>

Objective 1: To investigate the effectiveness of post-flood border insecticide treatments for the management of rice water weevil larvae in California rice.

The original goals for objective 1 were met and the work was done generally as planned. The spring weather delayed rice planting, but did not obviously effect the success and/or results for Objective 1. There may have been subtle effects which will not be apparent until we have a more "normal" year. The use of the standard, preplant Furadan 5G, was eliminated by the growers at some sites because, with the cool spring, growers knew they would have to drain the fields to facilitate seedling establishment. Water must be held for 28 days following Furadan application. This direct comparison was lost at a few sites.

Rice water weevil populations in 1998 were influenced by the unusual spring weather conditions. This insect, after it breaks the overwintering diapause, flies to infest newly-flooded rice fields. This spring flight occurs under specific conditions of warm (75^{0}F), calm evenings (7-11 pm). In 1998, these conditions were initially met from 19 to 22 April and from 26 to 30 April; a significant rice water weevil flight occurred during these times. We monitor rice water weevil flight every year with a light trap at the Rice Experiment Station. A total of 1185 weevils was captured in this trap from April to July 1998, compared with 2500 in 1997 and a recent peak of 5500 in 1996. About 90% of the weevils in 1998 were captured during this 10 day period of favorable weather (Fig. 1, 2). Generally, the flight is more evenly distributed over the 3 month period. In 1998, no rice had been planted when the primary weevil flight occurred. Rice water weevil adults apparently survived on weed growth on the levees until rice was planted. Upon field flooding/seeding, the adults quickly moved (crawled) into the fields. This may have concentrated the length of infestation to a few day period, which could have favored the performance of the short residual insecticides. Field infestations were generally average to above average in severity, but suffice to say that the normal infestation pattern was not followed.

Dimilin application had no effects on plant leaf scarring; this was expected since the activity of this product is through sterilization of the females rather than direct mortality. The average percentage scarred plants was 31% for the Dimilin entire basin treatment, 49% for the Dimilin border treatment, and 33% for the untreated. For rice water weevil larvae, numbers were too low at two of the five sites to draw meaningful results. Previous research has shown that densities need to average ~1 larva per core to warrant control measures, i.e., cause economic loss. At one location (Butte#1), the Dimilin application was made too late, according to the plant growth; the plant were at ~5 leaf stage. With the late seeding at this location (and hot temperatures) and demand for aerial applications at this time, the rice simply grew through the required stage before applications could be scheduled. As expected, the Dimilin did not provide any control at this location. At the remaining two sites, Dimilin provided good control and reduced the larval population below the economic threshold. There were no differences between the border and entire basin treatments (75.4% reduction in the entire basin treatment and 69.1% reduction in the border treatment). Across all five sites (including the site with the delayed application), averages were 1.3 rice water weevil per core sample (untreated), 0.2 (Furadan), 0.3 (Dimilin full basin), and 0.7 (Dimilin border treatment) (Table 2). Yield data (hand harvests) showed that overall the yields were lower in the Dimilin border treatment than in the Dimilin full treatment and that both of these yields were lower than with Furadan (Table 2). The untreated plots yielded ~6300 lbs. grain per A. With the machine harvest yield data, the yields of the four treatments were more similar. The hand harvest data are taken from the area with the highest rice water weevil populations and these data tend to maximize the effects of the pests; the machine harvest data represent the entire basin and give a more realistic picture of the results. Data from the two sites with economic rice water weevil populations and proper Dimilin application timing showed hand harvest yields of 6925, 5979, and 5891 lbs./A for the Dimilin full, Dimilin border, and untreated, respectively, and machine harvest yields of 7125, 6264, and 7503 for the Dimilin full, Dimilin border, and untreated, respectively.

Warrior provides rice water weevil control by killing the adults before oviposition. Data collected in 1998 showed that Warrior application significantly reduced the incidence of rice water weevil scarred plants. Averaged over the four locations, 21.6 and 44% of the plants were damaged in the Warrior (full basin) and untreated basins, respectively. The Warrior border treatment provided slightly better results (11.9% scarred plants). Larval control with Warrior was also good. The untreated averaged 1.7 larvae per core compared with 0.06 for the Warrior full basin treatment; the border treatment of Warrior was comparable with 0.08 larvae per core. Furadan resulted in 0.3 rice water weevil per core. These results are somewhat misleading in that only one field had a high rice water weevil infestation. In the other three fields, the population was low to moderate (below the threshold). In the field with the high infestation, Warrior provided 97% control. Yield data showed that the Warrior treatments yielded more than the untreated but substantially less than the Furadan. There were no obvious difference in the yields between the border and full basin Warrior treatments.

Objective 2: To demonstrate the effectiveness of a cultural technique, winter rice field flooding, for the management of rice water weevil in California rice.

This objective was greatly compromised by the inclement winter and spring weather in 1998-99. At the Colusa County site, there were no significant differences between the two treatments (in fact the results were the opposite of previous years) (Table 4). Egg density, incidence of scarred plants, and larval numbers were actually slightly higher in the winter-flooded compared with the non-flooded. The high incidence of winter precipitation and overall flooding undoubtedly altered the results. At the Butte County site, there was a low incidence of rice water weevil. A total of 5 eggs were found in both treatments over 2-week sampling period. Scar counts averaged 29% for the winter-flooded plots and 18.3% for the non-flooded treatment. The winter-flooded field had less oviposition and slightly lower percentage scarred plants compared with the non-flooded field at the Sutter County site (Table 5). The abnormal rice water weevil flight timing and infestation method may have influenced the 1998 results for this objective. A more favorable year in terms of weather will allow us to make more progress towards this objective.

d. Discussion:

Objective 1: To investigate the effectiveness of post-flood border insecticide treatments for the management of rice water weevil larvae in California rice.

In summary, both products (Dimilin® and Warrior®) appear to have potential to effectively control rice water weevil with border treatments. Additional work and sites are needed to add to the database and to validate the results. The lack of economic populations at ~50% of the sites is frustrating, but a reality when working with this pest. The flooded system and subterranean nature of rice water weevil make it a demanding pest on which to conduct research. A more normal year in terms of environmental conditions would also enhance the results. Timing is very critical with these products and will be a challenge for PCAs and growers. The post-flood application timing is new for California rice and there is certainly more to learn about optimizing the timing. If the border treatment is proven effective, this will reduce the cost for the grower and amount of insecticide applied to this aquatic system; these are all positive attributes. I am not aware of any other data collected in California in 1998 on Dimilin and Warrior efficacy against rice water weevil. An Experimental Use Permit was in place with Dimilin, but there was minimal data collection. My understanding is that growers were largely satisfied with the product performance. Our results in 1998 were similar to previous years results (Godfrey and Cuneo 1998) although your funding certainly allowed us to broaden and intensify our studies over that previously conducted. Our results have consistently improved as we have gained experience with the products. Results from other states (Muegge et al. 1998, Way et al. 1998, Bernhardt 1998, and see Arthropod Management Tests for other research) have been within the same range as ours, where applicable given the differences between the systems.

Objective 2: To demonstrate the effectiveness of a cultural technique, winter rice field flooding, for the management of rice water weevil in California rice.

The conditions in 1998-99 were not conducive to making progress on this objective. Nevertheless, we conducted studies toward this objective and gained some information regarding rice water weevil oviposition and timing. Data toward the primary comparison of winter-flooded and non-flooded were not promising and must be considered preliminary (at best) in light of the conditions.

e. Summary and Conclusions:

The efficacy of a modified insecticide strategy and a cultural control technique on rice water weevil (*Lissorhoptrus oryzophilus* Kuschel) was evaluated in field studies. The specific objectives of this work were 1.) to investigate the effectiveness of post-flood border insecticide treatments for the management of rice water weevil larvae in California rice and 2.) to demonstrate the effectiveness of a cultural technique, winter rice field flooding, for the management of rice water weevil in California rice. Researchers, Cooperative Extension personnel, agrichemical company representatives, and rice growers were involved in these studies. Preplant applications of a granular insecticide are the standard method of controlling rice water weevil in California; generally application is made only to the basin borders. Registration of the insecticide used for this treatment, Furadan, is scheduled for cancellation. Since 1991, the registration has been under scrutiny and the registration will likely be canceled when alternatives are available. Two products, Dimilin® 2L and Warrior® 2EC, used as post-flood treatments are in the registration process. These along with a preplant, incorporated product, Icon®, form viable alternatives to Furadan. Economic rice water weevil populations generally only occur in the first 30-50 feet of the field adjacent to the levees. Therefore, the standard application method with Furadan is to apply the insecticide only to this area. This method provides effective control and has the positive attributes of reducing the amount of insecticide used, cost, potential exposure, etc.

A key question regarding the use of post-flood products is if they will provide efficacious rice water weevil control when applied only to the borders of the field compared with applications to the entire basins. The optimal timing for these post-flood products is approximately the 3 rice leaf stage. There is very little foliage leaf area to intercept the insecticide at this time; most of the insecticide goes into the water. With a border treatment, the mixing of treated and untreated water may dilute the insecticide concentration and render the application ineffective. Studies for this objective were conducted in nine grower fields in 1998. Data showed that Dimilin provided good rice water weevil control and there was a slight trend for less efficacious control with the border than the full basin treatment. For the other prospective rice water weevil product (Warrior), studies showed excellent rice water weevil control and the border and entire basin treatments provided equivalent efficacy. At least two important considerations and qualifying statements must be made about the 1998 results. Economic rice water weevil populations occurred in about one-half of the locations. This is fairly typical of this insect, although this was probably influenced and compounded with overall infestations being somewhat lower in 1998 than previous years. The occurrence of the damaging stage, the larvae, in the flooded, mud environment makes it difficult to quickly *a priori* ascertain the presence of damaging populations. Secondly, the unusual spring environmental conditions may have influenced the results. In summary, the primary flight period of the insect was in late April; at this time no rice had been seeded because of the cool, wet weather. Therefore, it is likely that the adults survived on the weed-infested levees surrounding the rice fields until these fields were flooded and seeded. Upon seedling emergence, the adults likely immediately crawled into the fields. This may have altered the "normal" timing, severity, and pattern of infestation and resulted in an early "pulse" of weevil adults. The efficacy of short-residual products, such as those tested, may have been favored.

Yield data, collected from hand-harvested samples ~10 feet from the levees, showed that overall the yields were lower in the Dimilin border treatment than in the Dimilin full basin treatment and that both of these yields were lower than with Furadan. With the machine-harvest yield data, the yields of the three insecticide treatments, and the untreated, were more similar, but the same trends were seen as with the hand-harvests. Yield data showed that the Warrior treatments yielded more than the untreated but substantially less than the Furadan. There were no obvious differences in the yields between the border and full basin Warrior treatments.

Additional data are needed to expand the database and to further examine the efficacy of border treatments. A range of field locations, years, environmental conditions, etc. will provide robustness to the data.

Cultural controls are presently used, in part, to manage rice water weevil populations. Previous small plot research has shown that lower rice water weevil larval populations occur during the growing season in areas that were winter-flooded compared with non-flooded areas. This research in 1998 was extended to larger plots and to grower fields. The unfavorable winter and spring conditions greatly compromised this objective. Most rice fields were flooded to some extent during the winter of 1998. Three locations were examined. Rice plants were evaluated for rice water weevil adult feeding incidence, egg deposition, and larval population density. At one location, there were no differences in rice water weevil adult feeding incidence, oviposition, or larval densities between the winter-flooded and non-flooded. At a Sutter County grower field site, there was a tendency for a lower rice water weevil infestation in the winter-flooded site than the non-flooded field, but the data were inconclusive. A more favorable year in terms of weather will allow us to make more progress towards this objective.

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List of Publications Produced

No journal publications have been produced from the first year of this project. Reference has been made to these studies in several trade magazine articles. Data from this project were reported to rice growers at the Rice Field Day on 26 August (L. D. Godfrey. "Rice water weevil management with insecticides - changes for 1999?"). Poster displays were shown to the ~500 rice growers and industry personnel attending this field day (1.] T. D. Cuneo, L. D. Godfrey, and C. C. Baca. "Optimizing efficacy of new rice water weevil management tools- 1997-98" and 2.] L. D. Godfrey, T. D. Cuneo, C. L. Alexander, and C. C. Baca. "Rice water weevil flight and oviposition timing: Keys to managing this pest with postflood treatments"). Written abstracts of these presentations were also published:

Cuneo, T. D., L. D. Godfrey and C.C. Baca. 1998. Optimizing efficacy of new rice water weevil management tools- 1997-98. Calif. Rice Experiment Station Field Day Report. pp 4-6.

Godfrey, L. D., T. D. Cuneo, C. L. Alexander and C. C. Baca. 1998. Rice water weevil flight and oviposition timing: Keys to managing this pest with postflood treatments. Calif. Rice

Experiment Station Field Day Report. pp 8-9.

Godfrey, L. D. and T. D. Cuneo. 1998. Calif. Rice Experiment Station Field Day Report. pp 47-50.

Appendices

Table 1. Dates for seeding, insecticide application, scarring evaluation, and larval sampling from border treatment study.

		Date of				
Treatment	County	Seeding	Application	Scarring	First Larval Sample	Second Larval Sample
Dimilin	Sutter	18 May	12 June	15 June	2 July	13 July
Dimilin	Placer	18 May	8 June	11 June	1 July	16 July
Dimilin	Butte#1	8 June	26 June	29 June	17 July	22 July
Dimilin	Butte#2	13 June	1 July	9 July	20 July	23 July
Dimilin	Butte#3	26 May	15 June	19 June	15 July	21 July
Warrior	Colusa	2 May	21 May	16 June	24 June	6 July
Warrior	Yuba	21 May	4 June	9 June	29 June	10 July
Warrior	Butte	17 May	4 June	5 June	29 June	9 July
Warrior	Sutter	25 May	6 June	10 June	30 June	10 July

Table 2. Overall average rice water weevil per core, scarred plants, estimated hand and machine yields - grower fields, Sacramento Valley, Dimilin 2L, 1998.

Treatment	Rate/A	Type of Appl.	% Scarred Plants	Avg. RWW per core	Hand Yields (lb/A)	Machine Yields (lb/A)
Dimilin 2L	16 oz	full	30.8	0.30	6787.0	6601.0
Dimilin 2L	16 oz	border	48.6	0.7	5731.5	6184.0
Furadan 5G	10 lbs	PPI	3.0	0.2	7229.2	6945.7
Untreated	---	---	33.0	1.3	6276.8	6532.2

Yields corrected to 14% moisture.

Table 3. Overall average rice water weevil per core, scarred plants, estimated hand harvests - grower fields, Sacramento Valley, Warrior 2 EC, 1998.

Treatment	Rate/A	Type of Appl.	% Scarred Plants	Avg. RWW per core	Hand Yields (lb/A)
Warrior 2EC	1.9 oz	full	21.6	0.06	6970.3
Warrior 2EC	1.9 oz.	border	11.9	0.08	6853.5
Furadan 5G	10 lbs.	PPI	15.3	0.31	8173.3
Untreated	---	---	43.8	1.76	6161.0

Yields are corrected to 14% moisture.

Table 4. Rice water weevil egg and scar incidence and larval density data from winter-flooding study -1998.

Treatment	Eggs Deposited	Percentage Scarred Plants	Rice Water Weevil per Core Sample
Colusa County Site			
Winter-flooded	101[A]	22.3	6.3
No winter flood	79	32.7	2.2
Sutter County Site			
Winter-flooded	6[B]	12.6	NA*
No winter flood	21	16.7	0.7

[A] 8 to 29 June (12 to 33 days after seeding); total of 6 sample dates.
[B] Total of 4 sample dates.
* Furadan-treated.

Rice Water Weevil Flight 1997 & 1998

Rice Experiment Station, Biggs, CA

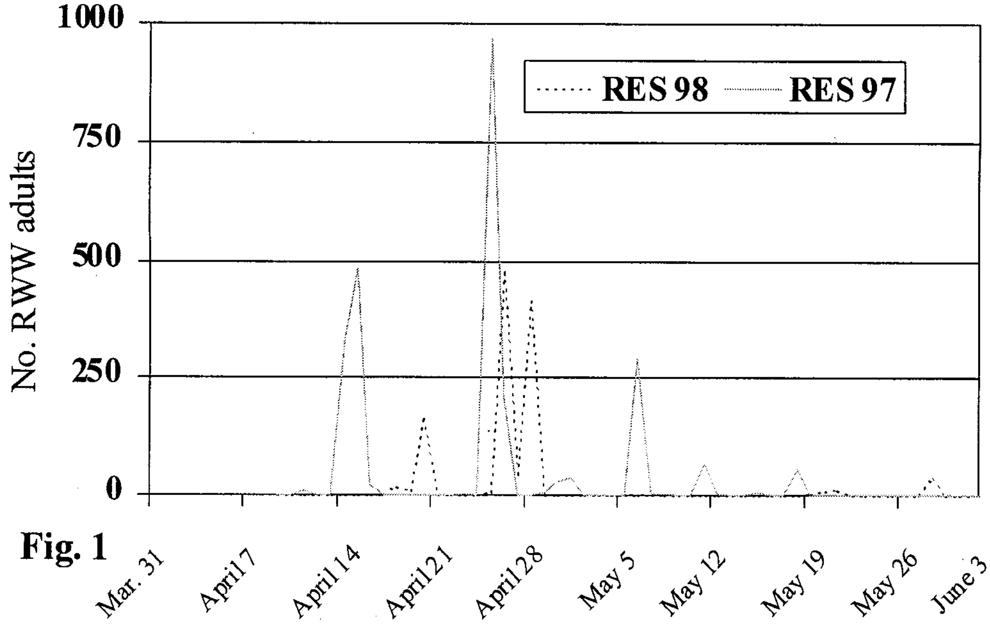

Fig. 1

Rice Water Weevil Spring Flight - 1991-98

Rice Experiment Station, Biggs, CA

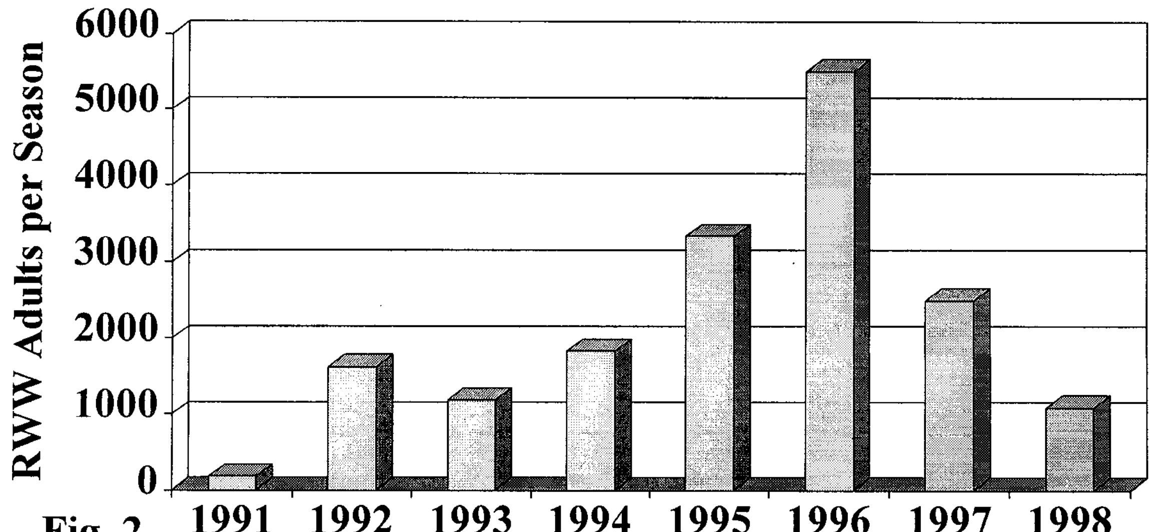

Fig. 2